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PROBABILISTIC CONVECTION INITIATION FORECASTS IN SUPPORT OF IHOP DURING THE 2002 SPC/NSSL SPRING PROGRAM

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1. INTRODUCTION

Since the mid-1990s, the Storm Prediction Center (SPC) and National Severe Storms Laboratory (NSSL) have cultivated a strong working relationship through mutual interest in operationally relevant research in Norman, OK. The cornerstone of this collaboration occurs during an intensive multi-week research effort conducted during the spring severe weather season each year. This effort has become known as the "Spring Program" (Kain, et al., 2003b).

Conducting a real-time research and forecast verification exercise such as the Spring Program requires a considerable commitment from all organizations involved, yet has received strong support by SPC and NSSL managers because project goals are carefully designed to address mission-critical interests of both organizations as well as the broader research and forecasting community. As a result, 2002 participation in this Program has expanded to include a wide range of scientists and forecasters from the National Center for Environmental Prediction's Environmental Modeling Center [NCEP/EMC], NOAA Forecast Systems Laboratory [FSL], National Weather Service Forecast Office, Norman, OK [WFO/OUN], NWS Warning Decision Training Branch [WDTB], and academia. Through participation in the Spring Program, research scientists benefit from working closely with forecasters by developing an appreciation for operational constraints and the practical limitations of various research products. In turn, forecasters benefit by learning more about various research tools and products that are being tested for possible operational implementation. In short, a major goal of the program is that forecasters are empowered to address operational forecast challenges from a more scientific perspective while researchers become better equipped to develop research projects that have operational relevance.

During 2000 and 2001, the emphasis of the Spring Program focused on critical SPC forecast products including the short term predictability of severe and non-severe thunderstorms and potential impact on operational convective watch lead time (Janish, et al., 2001). During 2002, the goals of the Program further concentrated on convective initiation (CI) in the vicinity of surface boundaries over the southern Great Plains. These forecasts provided a catalyst for evaluating operational and experimental mesoscale numerical models as well as providing forecasting support for various components of the International H_2O Project (Weckwerth, 2002). A full description of all Spring Program objectives, forecast products, models examined, evaluation/verification forms, and other related information is available on the 2002 Spring Program web site:

http://www.spc.noaa.gov/exper/Spring_2002/

2. FORECAST PRODUCTS AND DAILY OPERATIONS

Forecasting for IHOP was conducted in the SPC/NSSL Science Support Area (SSA), located directly adjacent to SPC operations, and a temporary operations center located at NSSL. Participants from the Spring Program as well as an FSL science team and special IHOP nowcasters provided a wide range of weather information to program organizers on time scales of hours to several days to assist with the diverse objectives and planning needs of the program. Spring Program support for IHOP was provided M-F from 13 May - 25 June 2002 and consisted of 2-3 "full time" participants and 1-2 visiting or "part time" participants. Full time participation was encouraged for periods of one week since it allowed time for team members to become familiar with equipment, procedures, forecast products and evaluation exercises. FSL science team members and other volunteers provided forecasts on weekends. The primary objective of Spring Program forecast products were to provide detailed outlooks of surface boundaries and probability of surface based convection initiation in and near the IHOP operations domain. The forecast domain was slightly larger than the IHOP operations domain (Fig. 1) to satisfy this objective.

Spring Program forecast products included a Day 1 (current day) and Day 2 (following day) CI forecast and overnight Day 1 Low-Level Jet (LLJ) and Mesoscale Convective System (MCS) forecast. The forecast team arrived each day by 7am and provided an initial briefing to IHOP organizers around 9am. Due to the flexible nature of IHOP missions, briefing times were often modified to meet specific needs with a member of the FSL science team providing weather information prior to 9am if

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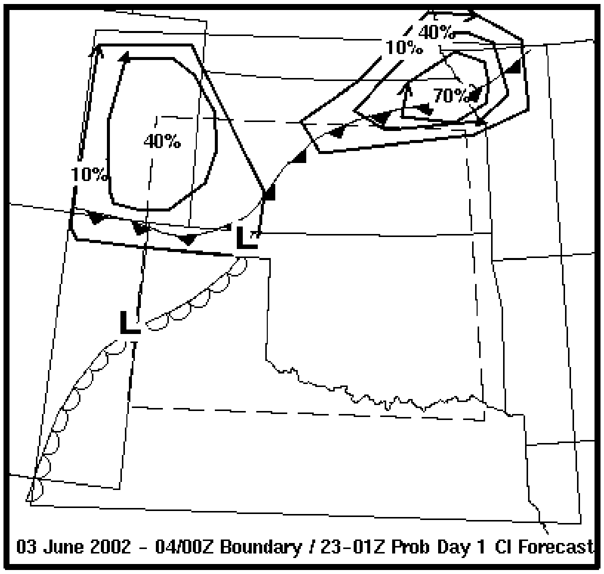

Fig. 1. Example of 2002 Spring Program / IHOP Day 1 Boundary and Probabilistic Convection Initiation Forecast issued 1700 UTC 3 June 2002 (valid 03/23-04/01 UTC). Dashed area is IHOP operations domain. Solid area is Spring Program forecast domain.

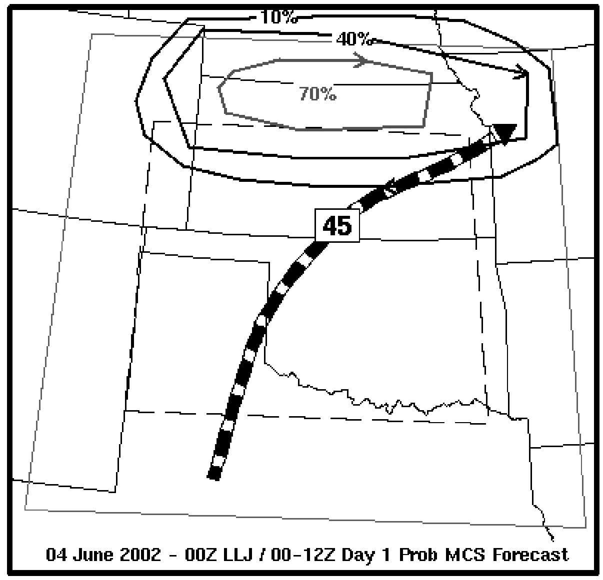

Fig. 2. Example of 2002 Spring Program / IHOP Day 1 LLJ and Probabilistic MCS Forecast issued 1700 UTC 3 June 2002 (valid 04/00-04/12 UTC). Dashed area is IHOP operations domain. Solid area is Spring Program forecast domain.

necessary. Following the morning briefing, participants refined all forecast products, using new model and observational data, and posted them to the web page prior to a daily science briefing with IHOP organizers at 12:00 noon. During the afternoon, nowcasting support was provided by the FSL science team and other IHOP participants in the SSA and temporary operations center allowing Spring Program participants to focus on other scientific objectives including subjective verification of the previous day's IHOP Day 1 CI and model forecasts. This time allowed for valuable scientific exchange regarding model performance and interpretation, providing insight into how forecasters use models, as well as the identification of model strengths and weaknesses in forecasting convection initiation.

2.1 Day 1 Convection Initiation, LLJ and MCS Forecasts

Experimental, high resolution Day 1 forecasts of CI, LLJ, and MCS activity were made each day during the Spring Program. The Day 1 CI forecast (Fig. 1) consisted of four (4) graphics each containing the expected locations of synoptic and mesoscale boundaries within the forecast domain, noting the character of each boundary (e.g. cold-, warm-, or stationary front, decayed outflow, dryline) valid at 18, 20, 22, and 00 UTC respectively. The graphic also included an assessment of the quantitative probability of deep, moist convection within 30 miles (either side) of a forecast boundary location. Three discrete probability values (10%, 40%, and 70%) were used to represent levels of forecaster confidence (low, medium, or high) in surface based convection initiation within (±) 1 hour of each boundary forecast (e.g. probability values for the 18 UTC boundary forecast represented a 2 hour period between 17-19 UTC). All forecast products were completed by 12:00 noon CDT (1700 UTC) daily such that the final forecast graphic represented up to an 8 hour lead time on thunderstorm development in the domain. The forecast team also explicitly indicated the time that initiation was most likely to occur and any areas where NEW convection initiation was expected to develop (delineated by an "X") within any 2 hour window on each graphic (when applicable). For the purposes of this study, initiation of deep, moist convection was defined as the first CG lightning strike associated with a convective updraft. A single text discussion accompanied the four Day 1 CI graphics focusing on model guidance and expected evolution of convection initiation and evolution across the IHOP domain between 17-01 UTC.

The Spring Program team also produced a Day 1 forecast for the nocturnal low level jet (LLJ) location and the probability of overnight mesoscale convective system (MCS) activity in the forecast domain. For the purposes of this exercise, the LLJ was defined as a wind maxima of 30 kt or greater at 850 mb, while an MCS was defined as a cloud system occurring in connection with an ensemble of thunderstorms which produces a contiguous precipitation area on the order of 100 km or more in the horizontal scale in at least one direction. These forecasts (Fig. 2) provided guidance for IHOP-QPF activities and consisted of a single graphic containing the forecast position and strength of the LLJ valid 12Z (the following morning), along with probability contours for the occurrence of an MCS within 30 miles of a point between 00Z-12Z. Three discrete probability values (10%, 40%, and 70%) represented discrete levels of forecaster confidence of MCS occurrence in the forecast domain.

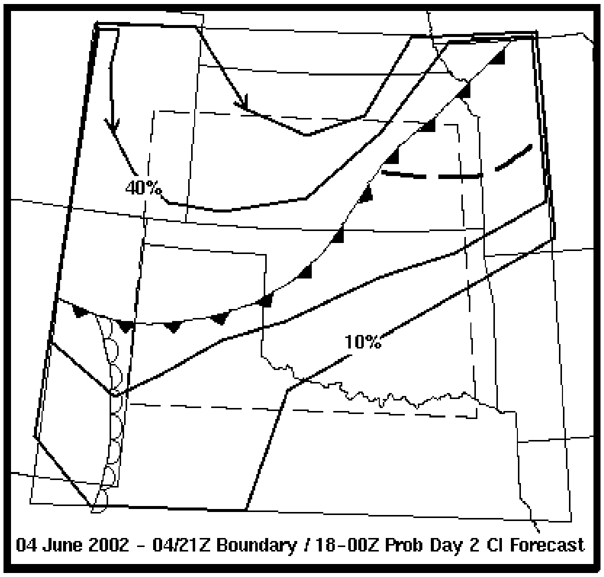

Fig. 3. Example of 2002 Spring Program / IHOP Day 2 Boundary and Probabilistic Convection Initiation Forecast issued 1700 UTC 3 June 2002 (valid 04/18-05/00 UTC). Dashed area is IHOP operations domain. Solid area is Spring Program forecast domain.

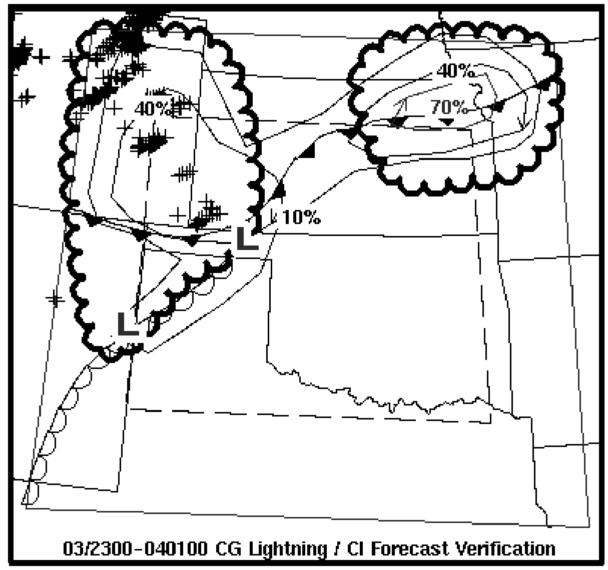

Fig. 4. Example of 2002 Spring Program / IHOP Day 1 Forecast and Model Parameter Verification Chart for 3 June 2002. Scalloped lines represent individual verification areas in the forecast domain. "+" signs indicate CG lightning strikes between 03/23-04/01 UTC.

2.2 Day 2 Convection Initiation Forecasts

An experimental Day 2 probabilistic CI forecast was created (Fig. 3) for IHOP. This forecast was similar to the Day 1 CI forecast except boundary positions were valid at 2100 UTC with probability of CI encompassing a 6 hour period from 18-00 UTC the following day. A single text discussion also accompanied the Day 2 CI graphic. This product and an overview of longer range model forecasts were discussed at the 12:00 noon science briefing to provide IHOP organizers with extended guidance for future operations.

3. FORECAST AND MODEL VERIFICATION PROCEDURES

During the afternoon, Spring Program participants focused on subjective verification of the previous day' s Day 1 IHOP and model forecasts. Web based forms, developed by programmers in the SPC Science Support Branch (SSB), allowed for systematic recording and archival of information during the process. Verification was done by comparing CG lightning and NIDS mosaic radar imagery with forecasts made the previous day using SPC workstations (N-AWIPS). In order to make evaluations meaningful, a subset of the forecast domain was chosen (scalloped line, Fig. 4). If multiple initiation or forecast areas were observed/made, supplemental forms were completed for each area. This was done in lieu of evaluating the forecast and model parameters over the entire domain which tended to result in a highly mixed signal regarding performance (e.g. difficult to rate performance if the model was good in one area and poor in another). The subset approach allowed for more robust data collection over an area of interest or concern which typically had a similar initiation mechanism and environmental conditions. Once an area was being evaluated, participation in recording information was done in a collaborative fashion with each participant filling out the form on a rotating basis. This ensured dialogue into how model guidance applied to the forecast and helped in the process to evaluate model performance.

In order to facilitate the subjective verification of IHOP forecasts within evaluation subset areas, participants had to provide information about the areal coverage of activity as well as placement of the forecast relative to actual initiation. Areal coverage was rated from 5 to -5 with increasing positive numbers representing an ***over*** forecast in coverage (e.g. very high confidence or large areas without any activity) and increasing negative numbers representing an increasing ***under*** forecast in coverage. A score of 0 implied a nearly perfect forecast. Evaluation of forecast "placement" was made relative to the forecast (e.g. if storms formed east of the highest probabilities, an eastward placement error would be noted). By examining placement and areal coverage, a fair assessment of model results could be obtained.

Forecasts from the 12 km Operational Eta model, 22 km EtaKF, 20 km RUC, and NCAR-WRF models were evaluated as well. The evaluation area was the same as for forecast verification, and focused on the following parameters; 1) Convective precipitation, 2) CAPE, 3) CIN, 4) Surface boundary location, and 5) Sounding structure. Each parameter was compared against observational and objectively analyzed surface data for verification. The subjective scoring system used for this exercise was from 0-10 with ZERO (0) indicating a poor forecast where information was incorrect (leading to an incorrect forecast assessment); FIVE (5) being a good forecast (capturing most features of significance); and TEN (10) being an excellent forecast (where all aspects of the forecast were correctly predicted by the model). Verification was done individually and in comparison with other models to determine a rank order for each parameter and model during the forecast period.

4. DISCUSSION AND RESULTS

Compilation of a data base focused on operational applications of numerical models and forecaster perspectives in the prediction of convective initiation is a complicated task. This effort requires not only access to full stream operational data, but a robust scientific exchange between forecasters and researchers. The SPC/NSSL Spring Program has fostered collaborative interaction between the two agencies as well as the larger scientific community to this end. Although full analysis of results compiled during the program will take some time to complete, interactive discussion and open dialogue in a real-time forecasting environment allowed for a more transparent infusion of new ideas based on fundamental scientific concepts to be integrated into SPC forecast operations. It also allowed for more direct feedback to researchers and other participants on how model data are used in operational forecasting, strengths and shortcomings of models in predicting real-time weather events, and sharing of new scientific concepts in development or under consideration, prior to formal implementation. As a result, this effort has resulted in an enhanced "spirit" toward applied research through the inclusion of participants in the local meteorological community (such as the Norman WFO and NWS/WDTB) as well as other national interests (NCEP/EMC, FSL, and academia).

In addition to an exchange of scientific ideas, collaboration during the Spring Program allowed SPC forecasters to further examine the value of full vertical resolution point forecast soundings and their time evolution. When combined with other diagnostics, this enabled forecasters to better understand and diagnose model processes (such as shallow convection). Such understanding was critical in helping forecasters gain confidence in the utility of a model forecast for a given scenario, which in turn helps forecasters develop confidence in the likely evolution of a convective event. Other benefits of the program such as exposure to new experimental models (via N-AWIPS or internet) or web based applications for data display, help stimulate new ideas for data analysis, and future technique development to help forecasters more efficiently use and integrate innovative data sets and displays into real-time forecast operations (Kain et al., 2002). Finally, our experience has shown that subjective verification procedures, as complimentary to objective techniques (Kain et al., 2003a), have helped operational meteorologists better assess model strengths and weaknesses as applied to various forecast scenarios, and provides alternate verification metrics to be considered in development of future numerical models.

5. ACKNOWLEDGMENTS

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